ABSTRACT

CHRISTIAN JASPER: The availability of water and sanitation facilities in schools contributing to health and educational outcomes: a systematic review
(Under the direction of Jamie Bartram, Claudia Gollop and Mark Sobsey)

A systematic literature review on the effects of water and sanitation provision in the school environment was performed. The goal of the review was to more fully characterize the benefits of water and sanitation in schools. This study has particular relevance in light of reports from communities on water and sanitation inadequacies in schools. Ultimately, forty-four papers met the inclusion criteria of exploring any effects of the provision or lack of provision of water and sanitation facilities in schools. The studies presented strong evidence for the provision of water for drinking in schools leading to adequate hydration, related to effects on cognitive abilities, continence issues, and potentially obesity. Evidence for the effect of handwashing services on outcomes of illness and absenteeism was supported and likewise for the effects of sanitation and sanitation services for menstruation. Strong evidence for the availability of the combination of water and sanitation services relating to outcomes of illness and absenteeism was found. The area of water and sanitation provision in schools has been widely addressed in peer-reviewed literature.

DEDICATION

Dedicated to my husband Micah, for helping me through it all, and for who you are. I love you.

ACKNOWLEDGMENTS

I would like to acknowledge and thank Tam Le for her help as my secondary reviewer, Dr. Bartram for his guidance in formulating and organizing my research, Dr. Gollop and Dr. Sobsey for their help in problem statement and methodology design and for serving as members of my committee. I would like to thank all of the librarians who helped me with my search methodology and questions, and in particular Corinne Farrell. I would also like to thank all of the countless others who helped informally in reflecting on the topic with me through conversation or in pointing me towards additional resources. I am thankful for your help, and know that this work would not be what it is today without your valuable input.

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INTRODUCTION

The United Nations Millennium Development Goal 2.A is to "ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling" (United Nations, Millennium Development Goals). The purpose of this goal is to provide the right of primary education to all children globally. However, sub-standard and inadequate water and sanitation facilities have been reported as a major hindrance to achievement of the goal of education by community and international organizations like the United Nations, and the World Health Organization, among others. Indeed, the World Health Organization has issued a goal in the Parma Declaration on Environment and Health to "...strive to provide each child with access to safe water and sanitation in homes, child care centers, kindergartens, schools...by 2020" (WHO, 2010).

Despite these commitments, many schools in lesser developed and developed nations still lack access to basic water and sanitation services, and concern for this issue is evidenced by the large body of literature on the topic. Naturally, the question arises as to how these inadequacies in water and sanitation in the school environment are impacting, or have the potential to impact, the educational and achievement processes in schools. The goal of this review is to more fully characterize all effects cited in the literature of adequate or inadequate water and sanitation access in the school environment, by cataloguing existing peer reviewed journal articles on the subject, defining the scope of effects, assessing the overall quality of the body of evidence, and highlighting any possible future research directions within the field.

METHODS

A systematic literature review was deemed most appropriate for this research as such reviews result in the definition, quantification, and assessment of the topic at hand. The purpose of this systematic literature review in particular was to more fully characterize the effects of water and sanitation provision, or lack thereof in the school environment on health, educational, and other outcomes. The ensuing method was reviewed by an experienced library science professor in the University of North Carolina, Chapel Hill School of Information and Library Science.

For the purposes of this review, water was defined broadly by us as either water for hand washing (water, wash basins, soap, and hand towels/drying devices,) or water for drinking. Studies on hand sanitizers were excluded. Sanitation was defined as the availability of facilities to urinate or defecate (private, safe toilets, latrines, and availability of toilet paper) or as sanitation facilities for women and girls to manage menstruation (private location, and availability of disposal mechanisms for menstruation materials).

The methodology involved a primary search based on specified search criteria keywords (presented below). All identified documents that aligned with these keywords based on title were then further screened based on title and abstract. The full text of documents that were included based on titles and abstracts were then read in order to determine whether they met the pre-defined inclusion criteria (discussed below). The review also involved searching all references in the bibliographies of included documents. Of these references, those that appeared relevant based specifically on the

title and abstract were also filtered through the corresponding review criteria. Finally, data was extracted from the included studies (presented in results and discussion sections). A secondary reviewer repeated all steps in the study. The purpose of including the secondary reviewer was primarily to further ensure that the included documents met the inclusion criteria, and that the excluded documents did not meet the inclusion criteria.

The following keywords were used in the searches: *Schools and Water or Sanitation, Gender and Water or Sanitation, Girls and Water or Sanitation, Menstruation and Water or Sanitation, School Absenteeism and Water or Sanitation, School Health Policies and Water or Sanitation, WASH (Water, Sanitation, and Hygiene) and Schools*

The inclusion criteria were any peer reviewed journal articles that explored any effects of providing or not providing water and sanitation at schools. Furthermore, these papers had to state an effect of this provision, or lack thereof, in terms of positive or negative outcomes, for example increased or decreased school attendance, school absenteeism or dropouts, health effects and so forth.

The following major scientific, electronic databases were searched during the months of October through December 2010: PubMed, Embase, Web of Science, the Cochrane Library, Science Direct, and Google. Programmatic sites specific to the topic of Water and Sanitation in Schools were excluded. The author did examine the publications available on numerous programmatic sites such as these, but in order to draw exclusively from the scientific evidence base, only journal articles from peer-reviewed sources were included.

Documents not written in English were included in the review only if an abstract and the full text document could be found in English. Any articles without abstracts or

full texts available were excluded. Dissertations were not included in this review. Studies exclusively examining the effects of behavior and behavior change related to water and/or sanitation in schools without any reference to modification of the environment through provision of water and sanitation were not included in this review, as health behavior offers a distinct realm. Flouride in drinking water was also excluded from the review, as the effects of fluoride on oral health in schools have been widely studied (Paraskevas et al., 2006). The population included in this review was schoolchildren and university students. Day care centers were not considered due to the varying outcomes expected in these environments, namely that they do not traditionally focus on providing education as a primary goal as do schools and universities.

RESULTS

Each stage of the screening process was completed with the criteria that all included articles must explore any effect of water or sanitation provision or lack of provision in the school environment. The primary search was performed based on title and identified three thousand four hundred and eighty-five references. The secondary review was based on abstracts of potentially relevant papers, and identified four hundred and seventy-one references. Forty-eight full text articles were found to meet the inclusion criteria after the full text tertiary review, however, three studies had multiple papers represented in the review and therefore only one article from each of these studies was included in the review. Ultimately, forty-four papers (n=44) were included in the data extraction process. Lists of all included studies can be found in the Appendix. Studies are presented in the discussion section based on the issue that they address: water for drinking, water for hand washing, sanitation, sanitation for menstruation, or combinations of these issues.

The range of issues addressed by the 44 papers meeting inclusion criteria is represented in figure 2 below. In short, six papers addressed sanitation provision in the school environment (n=6, 13.6%), three papers addressed sanitation related to female menstruation facilities in schools (n=3, 6.8%), ten papers addressed water for drinking in schools (n=10, 22.7%), five papers addressed water for hand washing in schools (n=5, 11.4%), three papers addressed both the provision of water for drinking and hand

washing in schools (n=3, 6.8%), and seventeen papers addressed the provision of both water and sanitation combined in schools (n=17, 38.6%) .

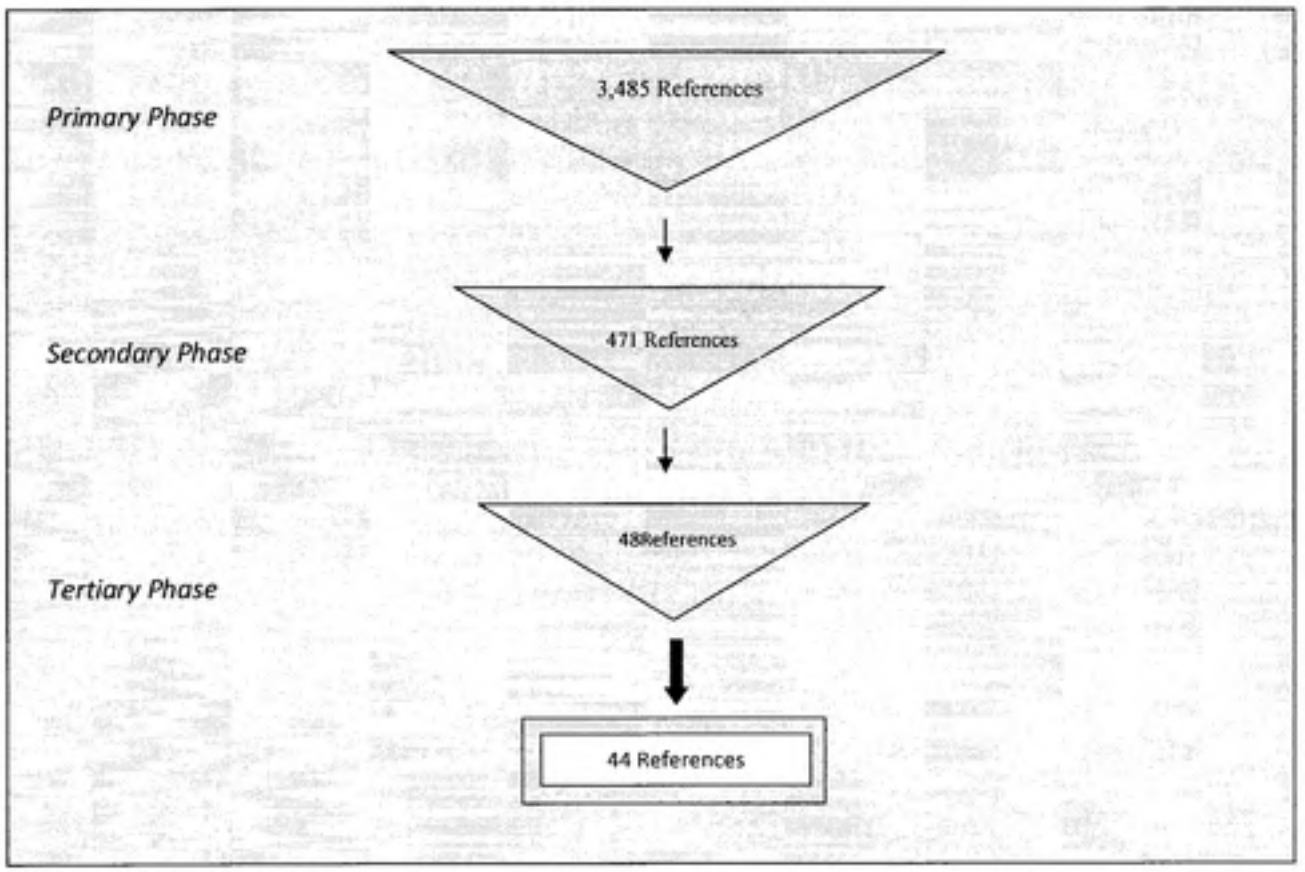

Figure 1: Systematic Literature Review Results during each screening phase and final number of included documents

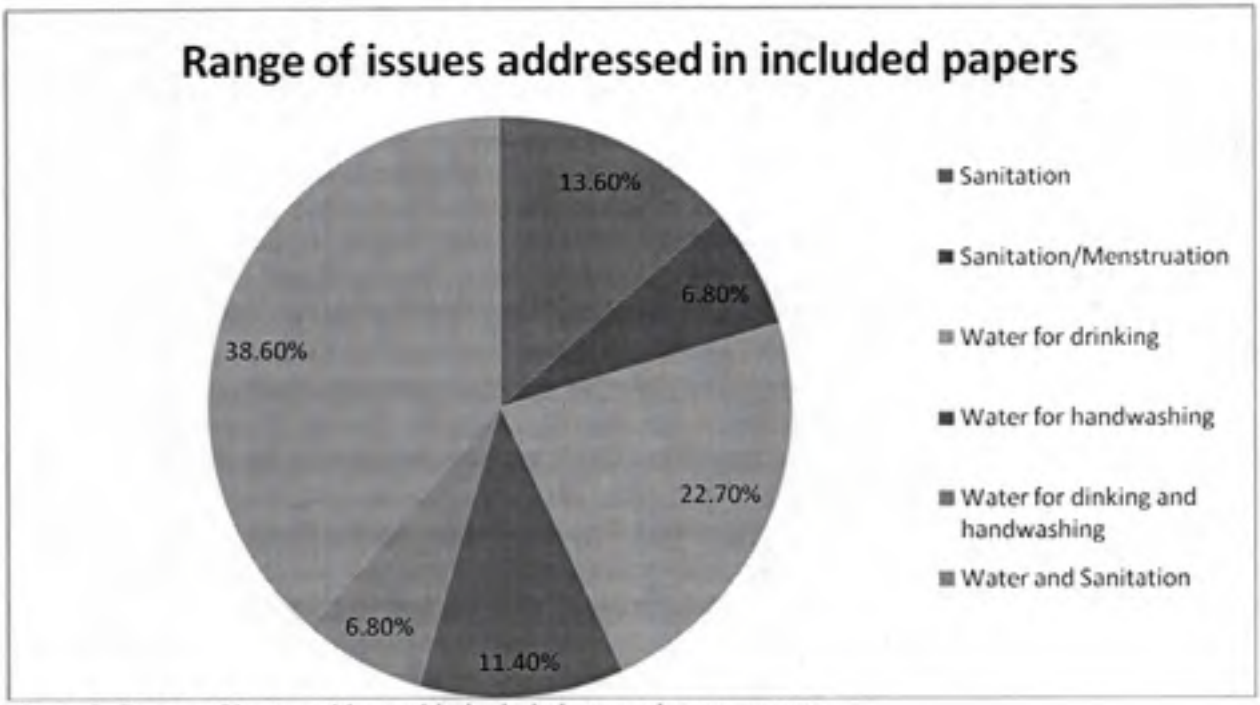

Figure 2: Range of issues addressed in included papers by percentage

An analysis of study populations revealed that all forty-four papers addressed students (n=44, 100%). Three out of forty-four papers focused specifically on the provision of facilities for girls and women relating to managing menstruation in schools (n=3, 6.8%) (Sommer 2010, Abrahams et al. 2006, Menstrual Hygiene Subcommittee of the Medical Women's Federation, 1949). Four out of all forty-four papers discuss teachers as well as students (n=4, 9.09%) (Samwel et al. 2009, Curin et al. 1999, Duran 2008, Abrahams et al. 2006). One out of forty-four papers discussed universities (n=1, 2.27%) (Scott et al. 2007). One out of forty-four papers considered day school and boarding students as study subjects (n=1, 2.27%) (Sommer, 2010).

The majority of articles, 31, were from the 2001-2010 time period (n=31, 70.5%). A graph of regions where studies were performed can be found in graph 3 below. Eight studies were performed in Africa (18.2%); four studies in Asia/Pacific Islands (9.1%); two studies in South America (4.5%); six studies in North America (13.6%); twenty-two studies in Europe (50.0%); and two studies in the Middle East (4.5%).

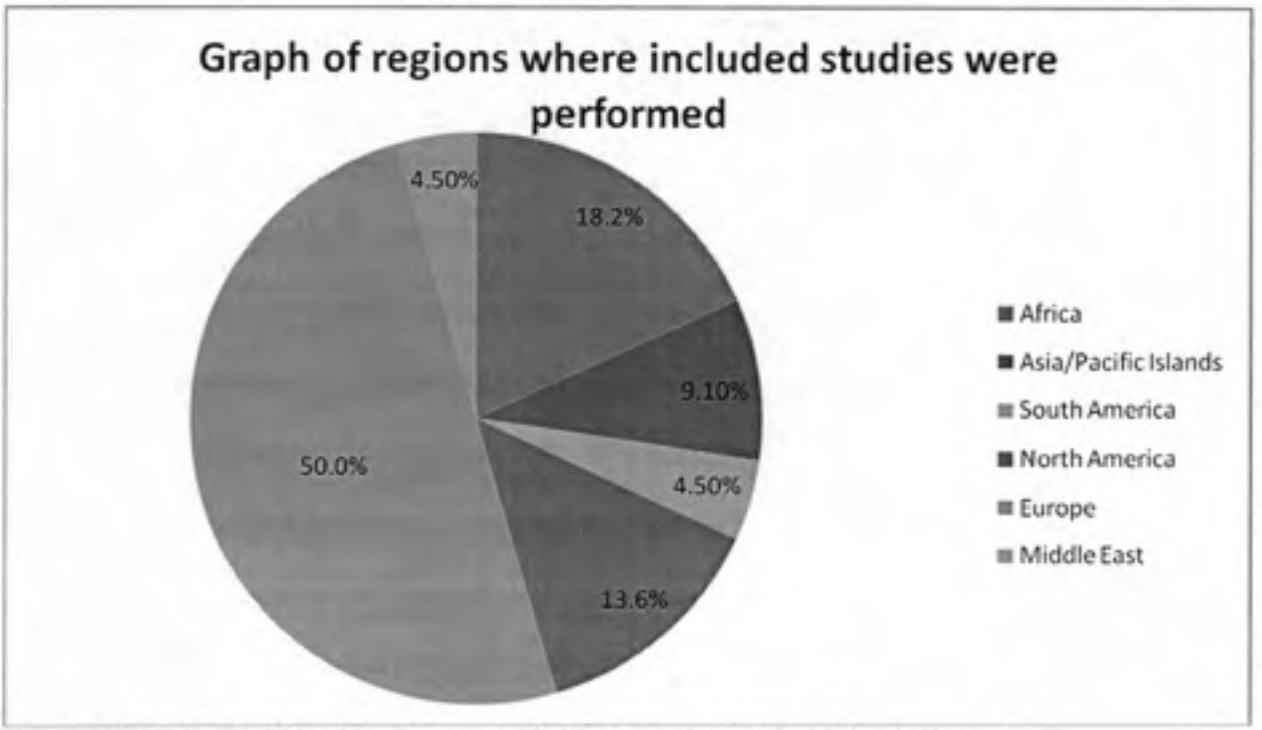

Figure 3: Description of regions where included studies were performed by percentage

The methods utilized in included studies are listed in figure 4 below. Many of these studies utilized more than one source of data collection, e.g. site observation in conjunction with surveys. The methods were as follows: nine studies included an intervention (alteration of physical school environment in relation to provision of water and/or sanitation, and may also have included education and follow up) (n=9, 20.5%); seven studies included were interviews, questionnaires, or focus group and observation of

the site (n=7, 15.9%); fourteen studies were analyses of publicly available data or questionnaires (n=14, 31.8%); two studies were solely site observations (n=2, 4.5%); three of the included studies were commentaries (n=3, 6.8%); and nine studies included microbiological analyses, observations of sites and/or a questionnaire. (n=9, 20.5%).

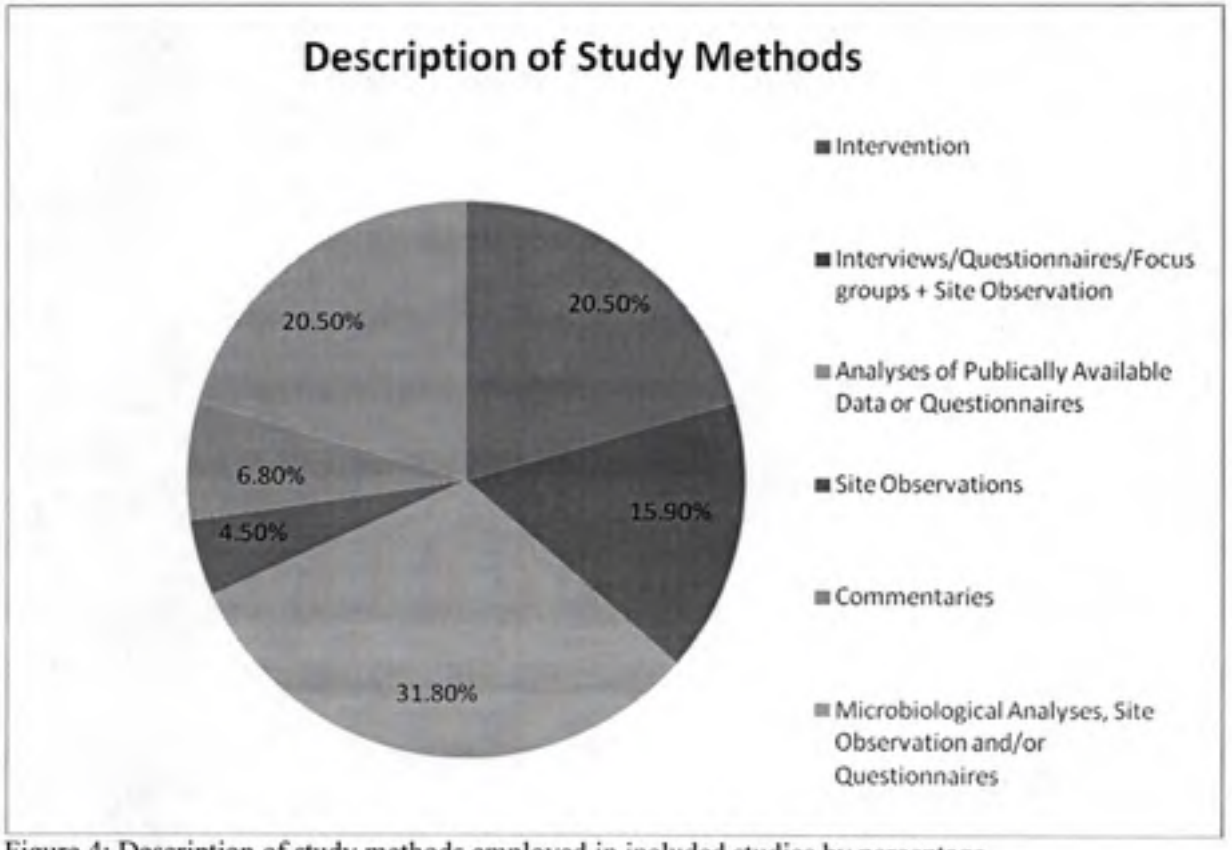

Figure 4: Description of study methods employed in included studies by percentage

The types of studies included were: Analytic studies were ten experimental interventions (n=10, 22.7%) and six observational studies (n=6, 13.6%); two participatory research studies (n=2, 4.5%); twenty-one studies were descriptive studies (n=21, 47.7%); three commentaries (n=3, 6.82); and two outbreak investigations (n=2, 4.5%).

The effects catalogued in the studies of water and sanitation provision, or lack of provision, can be defined broadly into those that discussed (Figure 5): absenteeism (n=7); physical harm, including slipping on frozen, soiled latrine floors (n=4); dehydration (n=4); obesity (n=2); gastrointestinal issues including avoidance of toilets leading to constipation, incontinence, and urinary tract infections (n=8); neuro-cognitive deficits as an outcome including mental performance and academic achievement (n=8); psychological outcomes such as fear, shame, embarrassment or discomfort to use the toilet (n=6); and infectious diseases as outcomes, including Hepatitis A, Helminthic infections, shigellosis among other diarrheal diseases, respiratory diseases and other communicable diseases (n=20). Other outcomes presented in papers included the lack of facilities and services leading to schools failing to serve as adequate role models on hygiene and therein undermining the efforts of teaching hygiene, which was not quantifiable (n=7).

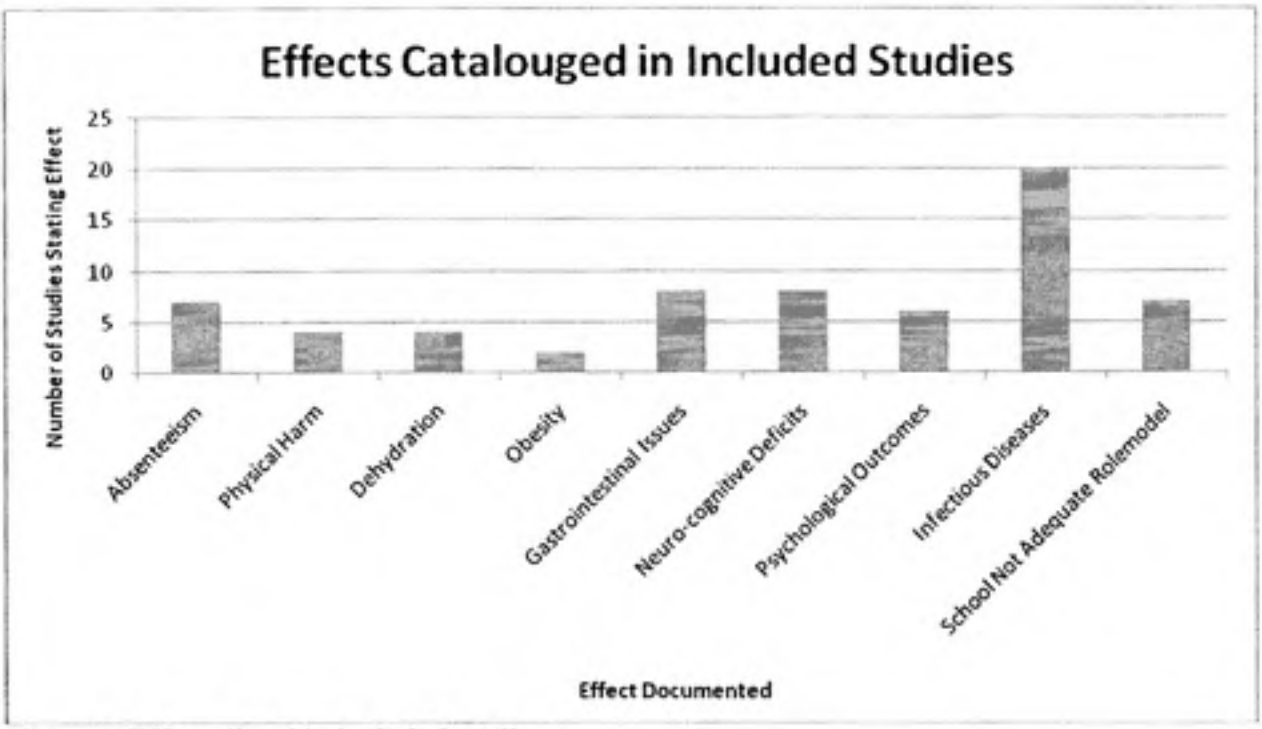

Figure 5: Effects listed in included studies

Although papers exclusively examining water and sanitation related to health behavior and behavioral modifications were not included in the scope of this study, many papers on this topic were identified through the search. A sizeable number of publications discussing water damage in schools (related to such health outcomes as mold and asthma) were found and excluded from the review, as they were outside the scope of this study. Likewise, a large number of studies on the effects of the provision of hand sanitizers was also noted during the review and excluded likewise as out of the scope of this study. These topics represent areas of potential future research.

DISCUSSION

It was considered less informative to discuss individually all 44 papers included in this review and as a more useful alternative the primary themes present in the body of evidence are discussed separately below.

Water for drinking

Ten identified studies dealt exclusively with the topic of drinking water provision in schools and three studies examined both water for drinking and for hand washing combined. A large portion of studies on water for drinking in schools were conducted in the United Kingdom and in the United States (n=9, 69.2%). The studies in this section are in agreement on their general findings of inadequacies in water for drinking provision and the benefits of said provision in schools. Triangulation of data collected through questionnaires, site observations, and analysis of records was present in most studies. (Triangulation of data techniques discussed in "Rigour and Qualitative Research," Mayes and Pope, 1995.) Six experimental interventions were in this body of literature; one of these interventions was a randomized control trial. In the body of literature there were two main areas pertaining to water in schools identified, namely water quantity related to provision and water quality issues relating to lead in school water.

The literature on water quantity issues revealed deficits in drinking water facilities in many schools, potentially leading to dehydration. Two survey studies published in 2000 and 2004 respectively revealed inadequate water facilities such as water fountains in schools in areas within the United Kingdom, potentially leading to inadequate hydration (Hunter et al., 2004, Haines et al., 2000). The included studies on water

provision cite the well-established effects of dehydration on health outcomes (Kleiner, 1999 and Charatan, 1999) such as decreased physical and mental capacity and continence problems like urinary tract infections or kidney stones.

There is evidence that the provision of drinking water facilities in schools increases hydration; three intervention studies showed that increased provision of water in schools led to statistically significant increases in water consumption and subsequent hydration, and one study showed a statistically significant effect of the provision of water on body weight. In two studies this significant difference was attained in conjunction with health education (Kaushik et al., 2007, Loughridge et al., 2005, Muckelbauer et al., 2009). Muckelbauer et al. 2009 showed a reduction in the risk of overweight after implementing a randomized control trial of providing drinking water and education in schools in Germany. The study showed a reduction in the risk of overweight by 31% in the intervention group (Muckelbauer et al., 2009). These studies demonstrate a well tested scientific basis for provision of water in school, indicating that water consumption and subsequently hydration, significantly increased with the availability of school drinking water.

In relation to water quality issues, four studies concentrated on lead in drinking fountains within schools in the United States. Interestingly, all of the included studies identified on lead exposure through school drinking water were conducted solely in the United States. Bryant, 2004 found that 57.4% of schools in Philadelphia had drinking water fountain lead levels above the USEPA 20 parts per billion standard for lead in schools and nonresidential buildings. This standard recommends action for schools with fountains or outlets with lead levels above 20 parts per billion (EPA, 1994, Bryant, 2004).

In his paper Berkowitz, 1995 indicated that, though lead solders were banned in New Jersey in 1987, testing from 1989-1992 revealed that 10% of schools and day care centers had lead in drinking water (Berkowitz, 1995). In Utah, a case of elevated lead in drinking water was identified by Costa et al. 1997, in an elementary school. Blood lead testing was performed in 116 students and all but one student demonstrated unremarkable blood lead levels of less than 10 mcg/dl (Costa et al., 1997). These results were possibly influenced by remediation efforts implemented in the school before blood level testing occurred (Bryant, 2004). Finally, a study by Sathyanarayana et al. in 2006 reported lead levels above EPA guidelines in a Washington State school. Blood lead levels were estimated based on the US Environmental Protection Agency Integrated Uptake Biokinetic Model for Lead in Children, and in the case of the Washington school were found to not be a significant source of lead exposure for students (Sathyanarayana et al., 2006).

The United States studies on lead indicate the potential for lead exposure to occur due to lead contamination in school drinking water sources. The neurotoxic effects of lead exposure on children, even at low doses, are understood and well documented (ATSDR). Blood lead levels were not tested in students in three out of the four studies, so actual exposures were not quantified in these studies. In their study though, Sathyanarayana et al. presented on a mechanism used to estimate potential blood lead levels typical and worst-case scenarios for exposure.

Water for handwashing

Five studies dealt solely with hand washing in schools and three studies examined both water for drinking and for hand washing combined. The studies in this section were generally in agreement on their findings of inadequacies in water for handwashing provision and the benefits of said provision in schools. Four experimental interventions were present in this area of literature, including two randomized control trials that implemented similar interventions, examined similar outcomes, and found differing results. These studies are discussed in further detail below. The majority of the studies in this section used surveys or questionnaires, and validated results through alternative techniques such as site observations, and analysis of records present (triangulation of data). The included literature revealed that a scarcity of materials for handwashing, such as water, soap, or towels for drying exists in some of the schools under study. Evidence in this body of literature suggests that the provision of water for handwashing and associated handwashing materials may lead to decreased absenteeism, decreased reported illnesses, and increases in knowledge.

Scarcity of supplies was noted in a United States survey study in 2007 on a college campus, revealing that 59% of residence halls on the campus provided no soap and 90% no paper towels. Thirty-one percent of respondents indicated that they did not wash their hands due to the lack of supplies for handwashing such as soap and hand towels (Scott et al., 2007). Lopez-Quintero et al. 2009 noted a scarcity of materials for hand washing in schools in a city in Colombia, where less than 7% of students reported access to materials on a regular basis. Responses to their survey indicated that children with access to hand washing materials were three times as likely to consistently wash their hands before eating, after toilet usage (Lopez-Quintero et al., 2009) and that those

who reported proper hand washing (before meals, after toilet use) were significantly less likely to report illness such as gastrointestinal and respiratory symptoms, and 20% less likely to be absent (Lopez-Quintero et al., 2009). These studies by Lopez-Quintero et al., 2009 and Scott et al. 2007 demonstrate a potential link between provision of hand washing services and subsequent handwashing behavior.

There is evidence for the effectiveness of the provision of water for handwashing and handwashing materials such as soap leading to decreased absenteeism and illness. Two interventions in Kenyan schools resulted in differences in rates of absenteeism and clinically reported cases of diarrheal diseases. Blanton et al., 2010 demonstrated through the provision of handwashing and drinking water stations (flocculent disinfectant, and hypochlorite solution) in conjunction with education of teachers and students at seventeen rural Kenyan schools a 26% decrease in absenteeism and a statistical difference in knowledge and behavioral changes in the homes of enrolled students in the schools (Blanton et al., 2010).

Migele et al. 2007 reported a decrease in the number of students visiting the local clinic for diarrheal illnesses in the months following their intervention in a rural Kenyan school. The intervention involved providing drinking water and handwashing stations (clay pots with narrow mouths, spigots, Waterguard solution, and two plastic tanks for handwashing) (Migele et al., 2007). Migele et al. note that the results of their study are not generalizable because the study was conducted in a non-traditional school funded by private donations and student fees, which allowed the funds to purchase water purification materials. This same approach however, was implemented in 70 additional public schools and was under evaluation at the time of the Migele et al. paper release. In

both the Blanton et al. and Migele et al. studies it is not possible to distinguish the individual effects of the handwashing and drinking water portions of the intervention.

In an interesting juxtaposition, two randomized control trials one performed in Israel (Rosen et al., 2006) and the other in China (Bowen et al., 2007) revealed markedly dissimilar results. The Rosen et al. study assigned intervention groups who received educational materials, training and environmental modifications in the form of soap and paper towel dispensers, cup racks and cups, and liquid soap and paper towels. The control group received neither education nor environmental modifications until the close of the study. After the intervention Rosen et al. found no significant decrease in rates of illness or absenteeism, but did find sustained handwashing behavioral change after 6 months (Rosen et al., 2006). Rosen noted that one possible reason for the inability to reach significance in decreases in rates of illnesses may be due to the smaller prevalence of target illnesses in the source population at the start of the intervention, compared to starting prevalence of target illnesses in populations of other studies (Rosen et al., 2006). In the Rosen et al. 2006 study the educators, research staff and parents, were blinded in respect to the outcomes (absenteeism, rates of illness and behavior change) the study was examining.

In their study in China, Bowen et al. 2007 designated standard intervention groups who received only education materials and training, while the expanded intervention group received educational materials, training, a peer handwashing monitor, and a supply of Safeguard soap for handwashing in schools. The expanded intervention group experienced significant reductions in episodes of illness and significantly reduced rates of absenteeism from schools. In this study the teachers, who recorded student absences,

were not blinded to the outcomes under study or the status of classrooms as intervention or control groups. However, since teachers in this population periodically record the statuses of student absenteeism due to local policies, there was no expected departure from standard practice.

The impact of hand washing on preventing communicable diseases has been well documented in the literature (Luby et al., 2005, Ejemot et al. 2008). The evidence presented in the studies included in this systematic literature review reflect the suggested importance of water provision for hand washing in schools, and the impact that regular availability of handwashing materials such as soap and towels can potentially have on hand washing behavior, rates of illness, such as gastrointestinal illness, and absenteeism.

Sanitation for menstruation

Only three studies focusing specifically on the provision of facilities for menstruation management in the school environment met the search criteria. The studies in this section are in agreement on their general findings of inadequacies in the availability of facilities for menstruation in the schools sampled. Two out of three studies in this section used participatory research study methods. Triangulation of data collected through questionnaires, coding of interview data, and site observations was present in most studies. No randomized control trials or experimental trials were present in the body of literature. One similar theme through all three papers on sanitation for menstruation was the discomfort and corresponding avoidance of school facilities during menstruation noted through surveys, focus groups, and interviews.

In a 1949 survey conducted in the United Kingdom on menstruation facilities in schools, inadequacies were revealed in facilities for management of menstruation, disposal of materials for menstruation, and assurance of privacy, leading to documented discomfort for girls at school, particularly in rural areas (Menstrual Hygiene Subcommittee of the Medical Women's Federation, 1949). More recently, Abrahams et al. in South Africa in 2006 and Sommer in Tanzania in 2010, documented through focus groups, interviews, and site observations the tendency for schoolgirls to avoid school during menstruation where there are inadequate facilities for privacy (locks or doors) and management of menses (Abrahams et al. 2006 and Sommer, 2010). A fear of sanitation facility utilization due to sexual attacks in school toilets located far from the school building was also noted (Abrahams et al. 2006)

Through surveys and site observations these studies revealed suggestive evidence for inadequacies in facilities for managing menstruation in some schools. The studies also provide some evidence for fear, discomfort and embarrassment of girls and women in utilizing school sanitation facilities for the management of menstruation. These concerns were captured primarily through focus groups, interviews and surveys. The potential for girls and women to avoid schools during menstruation due to inadequate facilities for menstruation was noted. Though one study included groups of school girls and school drop-outs in order to better understand the effects of menses and puberty on school drop-outs (Sommer, 2010), the exact effect that the lack of these facilities has on girl/women absenteeism and drop-outs from schools was not quantified through any of these studies. Furthermore, no research was found quantifying the proximity of school sanitation facilities from schools on rates on sexual assaults in sanitation facilities.

Sanitation

Six studies met the search criteria for sanitation, which is defined as the provision of sanitation facilities, toilets, latrines, stalls, locks, and materials for sanitation such as toilet paper, in the school environment. The studies in this section are in agreement on their general findings of inadequacies in sanitation provision and the benefits of said provision in schools sampled. All of the studies included in this area were descriptive studies, with no experimental interventions present. Triangulation of data collected through questionnaires, site observations, and analysis of public records was present in the majority of studies. Only one study in this area reported the results of an intervention conducted in a school. No randomized control trial was present in the body of evidence. In this area of literature there is some evidence through surveys conducted in separate countries that inadequacy of school sanitation facilities may lead to avoidance, and it has been documented in the literature that this avoidance leads to associated health effects. Additionally, there is at least some evidence for the contribution of the condition of school toilets on academic success and school attendance.

Samwel et al. 2009 observed poor standards of school toilets in Eastern European nations (Samwel et al., 2009); avoidance was documented among students, reportedly due to smelly, dirty toilets, which were located far from the school building. Reports of avoidance were documented among girls and teachers during menstruation and among other students, due to fear of utilizing facilities located far from the school buildings. A fear of slipping on floors covered with urine, which froze in winter in outdoor sanitation facilities, was also noted (Samwel et al., 2009). Surveys conducted by Barnes et al. 2002

in the UK and Lundblad et al. 2005 in Sweden, noted avoidance of school toilets due to sub-optimal standards (smelly, unclean, lack of privacy) and noted the potential risk for development of associated continence issues like urinary tract infections due to avoidance behaviors, documented in existing literature (Loening-Baucke, 1997). A study in Tanzania noted inadequate school sanitation facilities like temporary pit structures with no covers to prevent breeding of flies. The condition of the facility was posited to create a risk for transmission of diseases causing anemia, such as parasitic infections (Mwanri et al., 2001).

Finally, a study conducted in schools in New York City using publicly available city data examined the influence of the condition of school facilities on academic performance and attendance. The city data utilized in this study was the Building Condition Survey from 1997-1998, a survey performed by external contractors who assess the condition of school facilities within New York City. Two of the included indicators in this assessment were toilet sanitation and ratios of toilets to students/ toilets to teachers (Duran-Narucki, 2008). Other indicators included in the cumulative assessment included building condition of ceilings, doors, drain, waste and storms systems, interior wall conditions, window and stair conditions, among others. The study found that the condition of schools assessed using these multiple indicators, predicted students' academic success, defined as scores in English Language Arts and Math standardized tests, and school attendance. Interestingly through tests for mediation the author was able to determine that school attendance is a full mediator for grades in English Learning Arts and is a partial mediator for grades in Math courses (Duran-Narucki, 2008). This study considered toilet sanitation and ratios of toilets in addition to

other indicators in the analysis, therein the study was able to show the partial impact of poor school facilities, including toilet facilities, on student academic success and school attendance. It is not possible to determine the individual contribution of the toilet indicators in this analysis.

Combined Effects of Water and Sanitation

Seventeen studies dealt with the combined effects of water and sanitation in schools. Five studies on water and sanitation in schools reported inadequate water and sanitation facilities in schools through surveys and commentaries (Croghan, 2002, Fuijwara-Pichler et al., 2006, Jewkes et al., 1990, Perez, 2010, Schweiger, 1990). These inadequacies in water and sanitation facilities in schools raise cause for concern in light of the strong evidence presented in the literature for a relationship between water and sanitation provision in schools and infectious diseases such as diarrheal diseases and helminthic infections. The studies in this section are in agreement on their findings of inadequacies in water and sanitation provision and the benefits of such provision in schools sampled. Four observational studies were present in the body of literature. Most of these studies were well designed and reported tests for significant differences, and controlled for potential confounders. Two experimental studies were present. Seven of the studies were descriptive. Triangulation of data collected through validation methods such as questionnaires, site observations, and analysis of records was present in about half of these descriptive studies (n=4, 57.1%)

In 1973 Thomas and Tillett reported on Sonne dysentery in day schools and nurseries from an eighteen year study conducted in the United Kingdom. Schools

implicated with Sonne dysentery outbreaks exhibited inadequate toilet facilities (fecal soiled floors and toilet paper rolls) and lack of materials for handwashing compared to schools not experiencing outbreaks (Thomas et al., 1973). This difference was not tested for statistical significance.

Koopman's epidemiologic study in Colombia in 1978 provided strong evidence for a causal relationship between the adequacy of toilets (toilet facilities that are not easily broken by students, adequate supply of water, cleanliness, and provision of toilet paper, soap and towels for drying) and diarrhea and vomiting in the schools observed. A recommendation for adequate toilet facilities and water in schools was made based on these findings (Koopman, 1978).

In a paper published in 1992 on an outbreak of Hepatitis A in the United Kingdom, school toilets were implicated and a statistically significant relationship was documented for Hepatitis A infection and use of the toilet for defecation (Rajaratna et al., 1992). On investigation, the school involved in the outbreak was found to lack toilet paper, hand towels, and soap for handwashing (Rajaratna et al., 1992).

Hughes et al. 2004 in their study in the Pacific Islands found that the risk of helminthic infection in schools decreased with increased access to water for handwashing and toilets. Insufficient water supply, the availability of a canteen, regular water and sanitation maintenance and overcrowding in classrooms were found to be significantly associated with helminthiasis in schools (Hughes et al, 2004). The authors found "the risk of heliminthiasis in schools with no water supplied was at least 4.1 times higher than in schools with a water supply regardless of the water quality" (Hughes et al., 2004). Helminthiasis was found to be significantly associated with underweight, stunting and

anemia in the study population (Hughes et al., 2004). Further, the relationship between helminthic infection and impairment of cognitive abilities has been established in the literature (Sakti et al., 2002).

LIMITATIONS

Limitations in this study included the fact that thousands of references were screened, leading to the potential for error in inclusion or categorization of articles. The inclusion of a secondary reviewer in the systematic review process presumably helps to mitigate such errors. Due to the fact that studies were collected at one point in time, this review represents a snap shot of peer-reviewed papers published at the time of the review. The studies were conducted within various countries, which may lead to concerns on the generalizability of these results. Interestingly, though these studies were conducted individually in multiple locations world-wide, there seems to be a general consistency based on the body of evidence on the inadequacies in water and sanitation facilities in many school locations, and the corresponding effects of provision of such services. The results seem to address an issue that cuts across national and cultural boundaries.

RECOMMENDATIONS FOR FUTURE RESEARCH

This review revealed potential areas for future research based on gaps existent in the body of literature. Environmental chemical contaminants like lead have the potential to have large impacts on children's development, yet little research exists on prevalence of these contaminants in school facilities, particularly in countries outside of the United States. Lead exposures, as well as other potentially harmful environmental contaminants, are clearly an under-researched area warranting further investigation. This research area is of particular importance in resource poor settings such as public schools within the United States and in lesser developed nations, considering that all published journal articles on this topic were conducted in the United States.

Evidence exists, through focus groups and interviews, for a lack of private facilities to manage menstruation in schools to lead to discomfort and for some girls/women to avoid school during menstruation. Monthly absenteeism may be a hindrance to learning and advancement in education. To date no studies quantifying the effect that the lack of these facilities has on girl/women absenteeism and drop-outs from schools exists in the peer-reviewed literature. There is a need for further scientific studies in this area, in order to quantify the effect that the provision of facilities for menstruation management has on school absenteeism and drop-out rates.

This research is particularly essential in light of high drop-out rates of young women in many lesser-developed countries (Herz and Sperling, 2004). The correlation

between education and women's health, economic success and educational status has been well-documented in the literature (Roudi-Fahimi et al., 2003). Therefore, measures that retain women and girls in school are essential and may potentially have an impact on millennium development goals of achieving universal education and promoting women's gender equality and empowerment (Millennium Development Goals 2 and 3 respectively). There is an urgent need to understand the effect that the intersection of sanitation and menstruation has on girl/women absenteeism and the contribution of other potential co-variables.

Human dignity is a critical issue in the matters of water and sanitation for all people. Though the matter of dignity cannot be quantified or measured in a study, it becomes evident from statements with undertones referencing embarrassment or fear leading to avoidance of toilets at school (Abrahams et al., 2006, Sommer, 2010, Samwel et al., 2009, Menstrual Hygiene Subcommittee of the Medical Women's Federation, 1949,Vernon et al., 2003, Croghan, 2002) that dignity is lacking and must be provided.

Future studies should also examine the interactions between drinking water and sanitation provision in schools. It has been suggested in the literature that a link may exist between unwillingness to drink water at school in order to avoid using unsanitary school toilets. This interaction could potentially lead to insufficient hydration and corresponding health effects such as cognitive deficits and continence issues (Jones, 2003, Lopez 2010, Vernon et al. 2003).

Few included studies examined universities (n=1) or boarding schools (n=1). These areas are distinct due to the fact that university students residing in dorms and boarding school students generally spend a larger amount of time in school facilities and

may therefore experience varying outcomes. These environments represent potential areas for future research.

CONCLUSION

An apparent issue in reviewing the results of this literature search and analysis was the large number of studies using questionnaires or publically available data, which may be biased or have other deficiencies. In particular questionnaires present the risk of information biases in studies and may present a risk for misinterpretation of questions or under or over reporting of issues questioned. This factor was overcome in a large number of studies, by a triangulation of data such as coupling questionnaires with site observations or microbiologic analyses, in order to serve as validation sources.

A number of studies were interventions that were characterized by intensive observation, data collection, and follow up. It is noteworthy that a sizeable portion of the studies included were experimental interventions, and that randomized control trials were also present in the body of literature. Randomized control trials are the ideal epidemiological study of choice, as they can control for potential or unknown confounders.

Though children theoretically spend more time in the home environment, they may spend up to one third of the day-the majority of the waking day- in schools. This fact makes the school environment an ideal location for child interventions. Additionally, the school may be ideal for interventions aimed at mitigating infectious disease spread because children are introduced to more strains of pathogens in the school, due to the fact that more children are present, in contact, and using the facilities (Koopman, 1978). It is likewise important to note that interventions in the school may have the potential to have an impact on the hygiene behaviors of caregivers in the home (Blanton et al., 2007).

The data presented in the study categories revealed strong evidence for the effects of water for drinking in schools. Strong evidence was also found for the effects of the provision of water and sanitation in conjunction in schools. The other categories, water for handwashing, sanitation related to the management of menstruation, and sanitation revealed some evidence for the claims presented.

In summary, this paper presented the results of a systematic literature review on the effects of water and sanitation provision in schools. The goal of the review was to catalogue and characterize existing studies in the field. Potential areas for future research were identified, based on the review. The articles included in this review present strong evidence for: water for drinking in schools relating to the outcome of improved hydration and known well documented effects associated with hydration, such as improving cognitive abilities, protection from urinary tract infections and potentially protecting against obesity; the occurrence of and a need for further research on lead present in school drinking water facilities within and outside the United States; water and associated services such as soap and hand drying materials demonstrating impacts of handwashing on rates of illness and absenteeism; the role of and a need for additional peer-reviewed studies examining the effect of sanitation facilities for the management of menstruation on school absenteeism and drop-outs in girls/women; inadequate sanitation facilities leading to avoidance and possible associated health effects documented in the literature such as urinary tract infections; preliminary evidence of inadequate sanitation facilities contributing to decreased school performance and attendance; and finally strong evidence for the relationship between water and sanitation provision and protection from infectious diseases such as diarrheal diseases and helminthic infections.

Respiratory and gastrointestinal diseases are two of the leading causes of death for children globally (Bryce et al., 2005). Heminthiasis is estimated to affect over two billion people chronically and is known to cause under-nutrition, anemia, and cognitive and development deficits in children (Awasthi et al., 2003). It is due to this, that the evidence summarized in this paper showing a strong relationship between the provision of water and sanitation in schools and infectious diseases such as respiratory, gastrointestinal, and heleminthic diseases, has important implications for children's health worldwide.

Many authors called for the development of more comprehensive school place regulation on water and sanitation, similar to adult workplace regulations on hygiene in existence in some countries (Jewkes et al., 1990, Vernon et al., 2003, Fuijwara-Pichler et al, 2006, Perez, 2010). Such regulations could result in improved water and sanitation conditions in schools, which are of particular importance since children spend a large portion of their waking hours in schools. In the author's opinion, implementation of such regulations would serve to overcome or eliminate barriers to education, particularly in low resource settings where schools and their teachers, administrators and regulators may not fully understand or acknowledge the potential impact of water and sanitation on health, cognitive abilities, and attendance. In order to achieve universal access to education as a right for all children, the underlying factors of water and sanitation provision in the school environment and their demonstrated impacts on health and educational outcomes must be addressed.

APPENDIX, CHARACTERISTICS OF INCLUDED STUDIES

Study Name	Field Examined	Type of Study	Location	Sample Size	Study time
Abrahams, N., S. Mathews, et al. (2006). "Intersections of 'sanitation, sexual coercion and girls' safety in schools'." Tropical Medicine and International Health 11(5): 751-756.	Sanitation, Menstruation	Participatory Research	South Africa	Three public high schools, exact number of participants not stated	4 months
Adegbenro, C. A. (2007). "Effect of a school health programme on ensuring safe environments for primary school children." Journal of The Royal Society for the Promotion of Health 127(1): 29-32.	Water and Sanitation	Experimental intervention	Nigeria	10 primary schools	3 years
Barnes, P. M. and A. Maddocks (2002). "Standards in school toilets--a	Sanitation	Descriptive study	United Kingdom	85 children from 65 schools	2 months

questionnaire survey." J Public Health Med 24(2): 85-87.					
Berkowitz, M. (1995). "Survey of New Jersey schools and day care centers for lead in plumbing solder. Identification of lead solder and prevention of exposure to drinking water contaminated with lead from plumbing solder." Environ Res 71(1): 55-59.	Water for drinking	Descriptive study	United States, New Jersey	53 day care centers and 37 schools	unknown
Blanton, E., S. Ombeki, et al. (2010). "Evaluation of the Role of School Children in the Promotion of Point-of-Use Water Treatment and Handwashing in Schools and Households-Nyanza Province, Western Kenya, 2007." American Journal of Tropical	Water for handwashing and for drinking	Experimental intervention	Kenya	666 students at 17 schools	13 months

Medicine and Hygiene 82(4): 664-671.					
Bowen, A., H. L. Ma, et al. (2007). "A cluster-randomized controlled trial evaluating the effect of a handwashing-promotion program in Chinese primary schools." American Journal of Tropical Medicine and Hygiene 76(6): 1166-1173.	Water for handwashing	Experimental intervention, Randomized Control Trial	China	3,962 students at 87 schools	5 months
Bryant, S. D. (2004). "Lead-contaminated drinking waters in the public schools of Philadelphia." Journal of Toxicology - Clinical Toxicology 42(3): 287-294.	Water for drinking	Descriptive study	United States, Pennsylvania	292 school buildings	8 months
Burr, M. L., A. R. Davis, et al. (1978). "Diarrhoea and the drought." Public Health	Water for handwashing	Observational study	United Kingdom	291 schools	~1 month

92(2): 86-87.					
Chen, K. T., C. J. Chen, et al. (2001). "A school waterborne outbreak involving both Shigella sonnei and Entamoeba histolytica." Journal of Environmental Health 64(4): 9-13.	Water for handwashing and Water for drinking	Outbreak investigation	Taiwan	730 students	September , 1993
Costa, R. A., K. L. Nuttall, et al. (1997). "Suspected lead poisoning in a public school." Annals of Clinical and Laboratory Science 27(6): 413-417.	Water for drinking	Descriptive study	United States, Utah	1 school, 116 students had blood lead level testing performed	unknown
Curin, K. and S. Pavic (1999). "Hygienic conditions in elementary and secondary schools in the County of Split-Dalmatia." Arhiv za Higijenu Rada i Toksikologiju 50(3): 273-281.	Water and sanitation	Descriptive study	Croatia	22 primary and 12 secondary schools	1 year
Duran-Narucki, V. (2008). "School	Sanitation	Descriptive study	United States, New York	95 elementary schools	1 year

building condition, school attendance, and academic achievement in New York City public schools: A mediation model." Journal of Environmental Psychology 28: 278-286					
Ebong, R. D. (1994). "Environmental health knowledge and practice survey among secondary schoolchildren in Zaria, Nigeria." Environmental Health Perspectives 102(3): 310-312.	Water and sanitation	Descriptive study	Nigeria	192 students at 1 secondary school	3 months
Fujiwara-Pichler, E., A. Maddocks, et al. (2006). "Standards in school toilets: do extra resources make a difference?" J Public Health (Oxf) 28(3): 294-295.	Water and sanitation	Descriptive study	United Kingdom	92 students	2005
Haines, L., J.	Water for	Descriptive	United	201	Survey 1

Rogers, et al. (2000). "A study of drinking facilities in schools." Nursing Times Supplement 96: 2-4.	drinking	study	Kingdom	primary, junior and secondary schools in the first survey, 42 primary schools in the second survey	1995, survey 2 1998
Hughes, R. G., D. S. Sharp, et al. (2004). "Environmental influences on helminthiasis and nutritional status among Pacific schoolchildren." International Journal of Environmental Health Research 14(3): 163-177.	Water and sanitation	Observational study	14 Pacific Islands	3,826 children at 27 schools	16 months
Hunter, M. L., I. G. Chestnutt, et al. (2004). "Fluid for thought: availability of drinks in primary and secondary schools in Cardiff, UK." Int J Paediatr Dent 14(4): 267-271.	Water for drinking	Descriptive study	United Kingdom	107 state primary and 20 secondary schools	Survey
Jewkes, R. K. and B. H. O'Connor	Water and sanitation	Descriptive study	United Kingdom	37 schools	3 months

(1990). "Crisis in our schools: survey of sanitation facilities in schools in Bloomsbury health district." BMJ 301(6760): 1085-1087.					
Jones, M. (2003). "Down the pan. Many school toilet blocks are outdated and unhygienic." Nurs Stand 17(19): 27.	Water and sanitation	Commentary	United Kingdom	n/a	n/a
Kaushik, A., M. A. Mullee, et al. (2007). "A study of the association between children's access to drinking water in primary schools and their fluid intake: Can water be 'cool' in school?" Child: Care, Health and Development 33(4): 409-415.	Water for drinking	Experimental intervention	United Kingdom	298 students	3 months
Koopman, J. S. (1978). "Diarrhea and school toilet hygiene in Cali,	Water and sanitation	Observational study	Colombia	8,444 students	4 weeks

Colombia." Am J Epidemiol 107(5): 412-420.					
Lopez-Quintero, C., P. Freeman, et al. (2009). "Hand washing among school children in Bogota, Colombia." American Journal of Public Health 99(1): 94-101.	Water for handwashing	Observational study	Colombia	2,042 students at 25 schools	unknown
Loughridge, J. L. and J. Barratt (2005) "Does the provision of cooled filtered water in secondary school cafeterias increase water drinking and decrease the purchase of soft drinks?" Journal of human nutrition and dietetics : the official journal of the British Dietetic Association 281-286	Water for drinking	Experimental Intervention	United Kingdom	2,965 students at 3 schools	3 months
Lundblad, B. and A. L. Hellstrom (2005).	Sanitation	Descriptive study	Sweden	385 students	Survey during 2001

"Perceptions of school toilets as a cause for irregular toilet habits among schoolchildren aged 6 to 16 years." J Sch Health 75(4): 125-128.					
Menstrual Hygiene Subcommittee of the Medical Women's Federation (1949). "Supply and disposal of sanitary towels in schools." Lancet 1(6561): 925-927.	Sanitation, Menstruation	Descriptive study	United Kingdom	112 schools	Survey
Migele, J., S. Ombeki, et al. (2007). "Diarrhea prevention in a Kenyan school through the use of a simple safe water and hygiene intervention." Am J Trop Med Hyg 76(2): 351-353.	Water for handwashing and Water for drinking	Experimental Intervention	Kenya	380 students at 1 private school	~1 year of study results presented (interventi on ongoing)
Muckelbauer, R., L. Libuda, et al. (2009). "Promotion and provision of drinking water in schools for overweight prevention:	Water for drinking	Experimental Intervention, Randomized Control Trial	Germany	2,950 children at 32 schools	1 school year

randomized, controlled cluster trial." Pediatrics 123(4): e661-667.					
Mwanri, L., A. Worsley, et al. (2001). "School and anaemia prevention: current reality and opportunities--a Tanzanian case study." Health Promot Int 16(4): 321-331.	Sanitation	Descriptive study	Tanzania	131 children, 76 teachers at 76 schools	1 month
O'Reilly, C. E., M. C. Freeman, et al. (2008). "The impact of a school-based safe water and hygiene programme on knowledge and practices of students and their parents: Nyanza Province, western Kenya, 2006." Epidemiology and Infection 136(1): 80-91	Water for drinking, Water for handwashing	Experimental Intervention	Kenya	390 students at baseline and 363 at follow up at 9 public schools	1 year
Perez, J. (2010). "Minimum standards for school toilets are needed to	Water and sanitation	Descriptive study	United Kingdom	~130 schools	Survey

improve child health." Nurs Times 106(24): 30.					
Rajaratnam, G., M. Patel, et al. (1992). "An outbreak of hepatitis A: school toilets as a source of transmission." J Public Health Med 14(1): 72-77.	Water and sanitation	Outbreak investigation	United Kingdom	283 students at 1 school	~2 months
Rosen, L., O. Manor, et al. (2006). "Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools." Preventive Medicine 42(1): 27-32.	Water for handwashing	Experimental intervention, Randomized Control Trial	Israel	1029 students at 40 preschools	6 baseline days, 66 study days
Samwel, M. and S. Gabizon (2009). "Improving school sanitation in a sustainable way for a better health of school children in the EECCA and in the new EU member states." Desalination 248(1-3): 384-	Sanitation	Descriptive study	Eastern European nations	unknown	unknown

391.					
Sathyanarayana, S., N. Beaudet, et al. (2006). "Predicting children's blood lead levels from exposure to school drinking water in Seattle, Washington, USA." Ambul Pediatr 6(5): 288-292.	Water for drinking	Descriptive study	United States, Washington state	71 elementary schools	2004-2005
Schweiger, M. (1990). "Crisis in our schools." British Medical Journal 301(6763): 1278.	Water and sanitation	Commentary	United Kingdom	n/a	n/a
Scott, E. and K. Vanick (2007). "A survey of hand hygiene practices on a residential college campus." Am J Infect Control 35(10): 694-696.	Water for handwashing	Descriptive study	United States	994 students	4 weeks
Sommer, M. (2010). "Where the education system and women's bodies collide: The social and health impact of girls' experiences of	Sanitation, Menstruation	Participatory Research	Tanzania	Interview: 10 in-school girls and 6 drop-outs. Participatory Research: Urban site, 60 in-	4 weeks

menstruation and schooling in Tanzania." Journal of Adolescence 33(4): 521-529.				school girls and 20 school dropouts. Rural site, two groups of in-school girls (n =10–20 per group)	
Thomas, M. E. and H. E. Tillett (1973). "Sonne dysentery in day schools and nurseries: an eighteen-year study in Edmonton." J Hyg (Lond) 71(3): 593-602.	Water and sanitation	Observational study	United Kingdom	19 primary 11 secondary schools, and 4 nurseries	1951-1968
Udo, S. M. and M. E. Eja (2004). "Prevalence and antibiotic resistant Shigellae among primary school children in urban Calabar, Nigeria." Asia Pac J Public Health 16(1): 41-44.	Water and sanitation	Descriptive study	Nigeria	593 students at 3 primary schools	4 months
Ulukanligil, M. and A. Seyrek (2003). "Demographic and parasitic infection status of schoolchildren	Water and sanitation	Observational study	Turkey	1,820 students at three primary schools	1 month

and sanitary conditions of schools in Sanliurfa, Turkey." BMC Public Health 3: 29.					
Upadhyay, V., J. Mathai, et al. (2008). "Primary school children: Access to toilets." Acta Paediatrica, International Journal of Paediatrics 97(11): 1546-1549.	Sanitation	Descriptive study	New Zealand	46 schools	Survey
Vernon, S. (2003). "Toilet facilities in schools." Nurs Times 99(19): 50.	Water and sanitation	Commentary	United Kingdom	n/a	n/a
Vernon, S., B. Lundblad, et al. (2003). "Children's experiences of school toilets present a risk to their physical and psychological health." Child Care Health Dev 29(1): 47-53.	Water and sanitation	Descriptive study	United Kingdom/ Sweden	United Kingdom 394 students in 10 schools and in Sweden 157 students in 7 schools	Survey
Wallis, E. M. and K. B. Dorman (1970).	Water for drinking	Experimental intervention	United Kingdom	427 students at 2 schools	Summer 1968

"Drinking water in schools." Public Health 84(4): 191-193.					

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